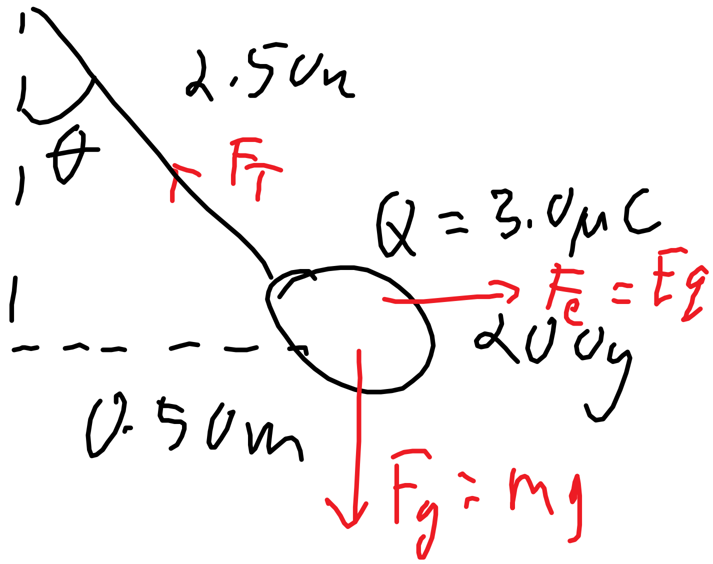
Monday, February 27, 2017 8:47 AM

Electrostatic Potential Energy and Voltage (Electrostatic Potential)

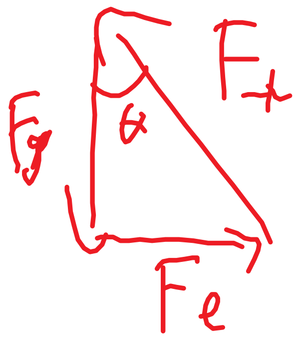
homework:

a) A balloon has a mass of 20.0 g and hangs from a 2.50 m string. If the charge on the balloon is 3.0 μC and it gets deflected by 0.50m what is the electric field strength?



$\sin\theta = \frac{0.5}{2.5}$

$\theta = 11.54$



$\tan\theta = \frac{F_e}{F_g}$

$F_e = F_g \tan\theta$

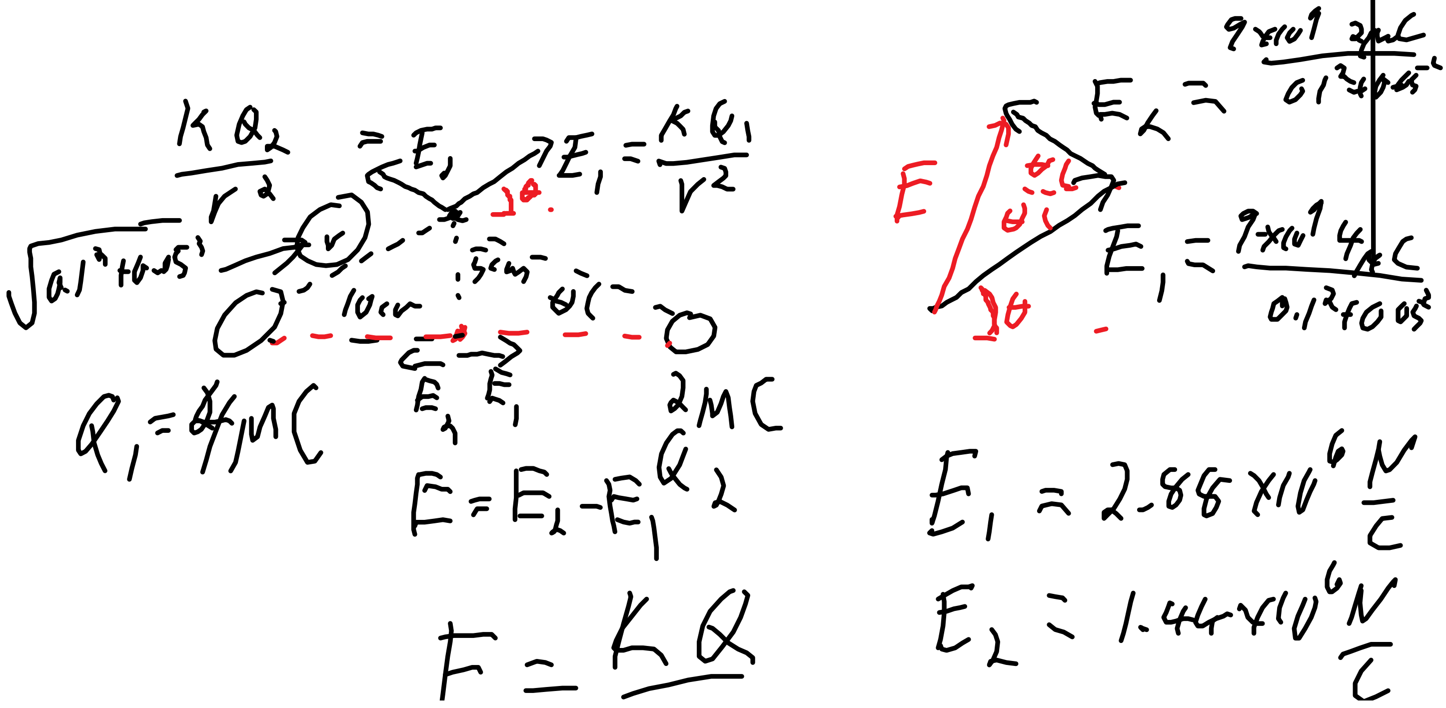
$E = \frac{F_e}{q}$

$Eq = mg\tan\theta$

$$E = \frac{(0.020\,kg)(9.80\,\frac{N}{kg})\tan 11.5°}{3.0 \times 10^{-6}\,C}$$

$$E = 1.3 \times 10^{5}\,\frac{N}{C}$$

A 2 μC and 4μC charge are 20cm apart. what is the electric field strength 5.0cm above the midpoint? (need cosine law)



$E^2 = E_1^2 + E_2^2 - 2E_1E_2\cos 2\theta$

$\theta = \tan^{-1}\frac{0.05}{0.1} = 26.57°$

$E = 2.32 \times 10^6\ \frac{N}{C}$

Electrostatic Energy, E_e and Voltage (Electrostatic Potential), V.

Recall gravity

Uniform field	General
E_g=mgh if g is uniform like near Earth	E_g=-GMm/r use if g is not uniform, like around any planet star

What's your guess about electrostatics

Uniform Field	Point Charge
ΔE_e=-qEd d in the direction of E	E_e=kQq/r relative to zero at r approaches infinity

derive these equations from
W=Fd = qEd
or W = integral of Fdr = kQq/r

eg.

1. Millikan is famous for determining the charge of an electron by levitating oil droplets into a uniform electric field. Say a 0.20g oil drop has 5 electrons (q=1.602 x 10^{-19}C each), what electric field strength would be required for levitation?

$$mg = Eq \qquad E = \frac{0.0002(9.8)}{5(1.602\times10^{-19})}$$

$$E = 2.45\times10^{15}\ \frac{V}{C}$$

1. What is the electrostatic energy of the electron in a hydrogen atom, radius 5.0 x 10^{-11}m?

$$F_e = \frac{kQq}{r} = \frac{9\times10^{9}(1.602\times10^{-19})(1.602\times10^{-19})}{5\times10^{-11}}$$

$$E_e = -4.6\times10^{-18}\ J$$

relative to zero at $r\to\infty$

Electrostatic Potential - Voltage

is the energy per unit charge
$V=E_e/q$
uniform field, or E given,
$\Delta V=-qEd/q = -Ed$
if d is in the direction of the electric field, E

around a point charge, Q
$V=kQ/r$ relative to zero at infinity

units: Volt, V = J/C

eg. You put a 9.0 V battery across two parallel plates, 4.0 mm apart to produce an electric field.

a) what is the magnitude of the electric field?
b) You accelerate an electron through a potential of 700V, what is the i)kinetic energy of the electron? ii) velocity?
c) keeners: the electron from b goes into the electric field from a, perpendicular to E. What is the force on the electron? if the plates are 12 cm long, how far is the electron deflected from its original path?

Homework - do this question and practice test
test Friday

Quiz
Q1

$F_{up}=F_{down}$
$2F_t\sin\theta = F_g$

2x250xSin(35)=286.788218175523 = 2.9×10^2N
2x250xSin(45)=353.5533905932737 = 3.5×10^2N
2x250xSin(55)=409.5760221444959 = 4.1×10^2N

2a)
$\tau_c=\tau_{cc}$
$m_1gL/2 + m_2gL = F_t\sin30L$
F_t = ((600/2)+(1500))/(Sin(30))=3600N
= ((900/2)+(1500))/(Sin(30))=3900N
= ((1100/2)+(1500))/(Sin(30))=4100N
b) $F_x = F_t\cos\theta$ is compression
3600.0xCos(30)=3117.69145362398 =3.1kN
3900.0xCos(30)=3377.499074759311 =3.4kN
4100.0xCos(30)=3550.704155516199 =3.6kN

3.
$\tau_c=\tau_{cc}$
$m_1gr_1 + m_2gr_2 = F_bL$
F_b = ((50x9.8x4)+(65x9.8x5))/8=643N
((30x9.8x4)+(65x9.8x5))/8=545N
((50x9.8x4)+(85x9.8x5))/8=766N

F_a = fdown - fup
= (50x9.8+65x9.8)-643=484 N
= (30x9.8+65x9.8)-545=386 N
= (50x9.8+85x9.8)-766=557 N

a) increase

$\tau_c = \tau_{cc}$

$m_1 g r_1 \sin\alpha + m_2 g r_2 \sin\alpha = F_b L \sin\theta$

((20x9.8x2xSin(30))+(75x9.8x3xSin(30)))/(4xSin(60))=375N or 410N or 350N

b) F= root($F_f^2 + F_N^2$) = Sqrt(375^2+(95x9.8)^2)= 1.0kN or 1.1kN or 1.0 kN

p438

Q28

E= 3.0×10^4 N/C uniform in parallel plates

d=1.6 cm

v=?

m=9.11×10^{-31}kg

q=1.602×10^{-19}C

E=F/q F=ma   a= Eq/m $v_f^2 = v_i^2 + 2ad$

or W=Fd = ΔE_k

$Eqd = 1/2mv^2$

v = root(2Eqd/m) = root($2(3\times10^4)(1.6\times10^{-19})(0.016)/9.11\times10^{-31}$)

v= Sqrt(2x3x1.6x0.016/9.11)=0.12984834521554

1.3×10^7 m/s

Electrostatic Potential energy, E_e and Electrostatic Potential, V or Voltage

They are not the same thing!

1. Millikan is famous for determining the charge of an electron by levitating oil droplets into a uniform electric field. Say a 0.20g oil drop has 5 electrons ($q=1.602 \times 10^{-19}$C each), what electric field strength would be required for levitation? If the electrons jump off the oil drop, what is the work done on the electrons if they move 1.0 cm in the direction of the field?
2. What is the electrostatic energy of the electron in a hydrogen atom, radius 5.0×10^{-11}m, relative to zero at infinity?

1. Fg=Fe
mg=Eq

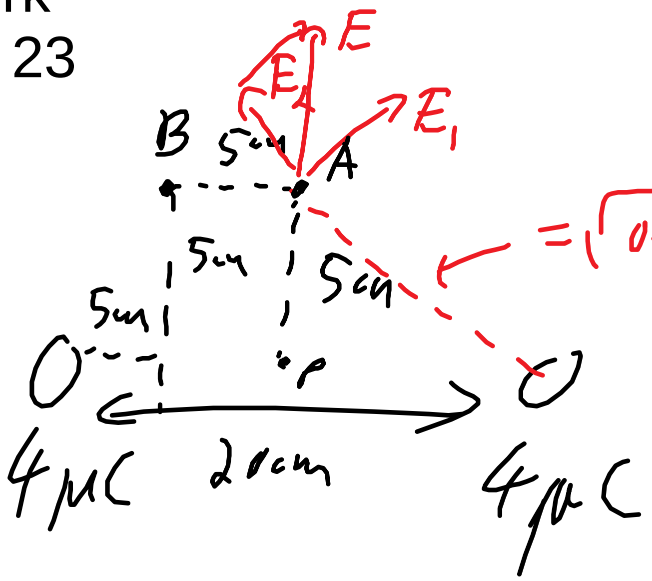
$E=mg/q= 0.0002x9.8/(5x1.602x10^{-19})=$
$= 2.4x10^{15}$N/C

$W=qEd = 5x1.602x10^{-19}x2.4x10^{15}x0.01=$
2.0×10^{-5}J

2.

$E_e=kQq/r =$
$9x10^{9}x1.602x10^{-19}x(-1.602x10^{-19})/5x10^{-11}$
$= -4.6x10^{-18}$J

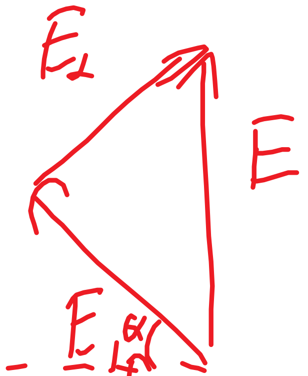
Homework
Q19 and 23



$= \sqrt{0.1^2 + 0.05^2} = r$

$$E_1 = \frac{kQ}{r^2} = \frac{9\times10^9 (4\times10^{-6})}{(0.1^2 + 0.05^2)}$$

$$= 2.88 \times 10^6 \ \frac{N}{C}$$

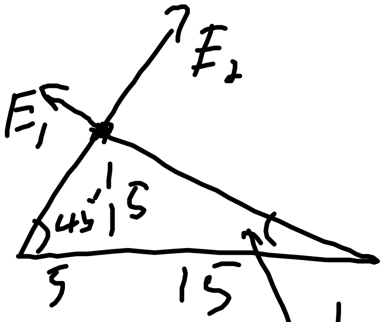


$$\theta = \tan^{-1}\frac{5}{10} = 26.57^\circ$$

$$E = 2(\sin 26.57)\, 2.88\times10^6 \ \frac{N}{C}$$

$$= 2.58 \times 10^6 \ \frac{N}{C} \quad \text{up}$$

b)



$\tan^{-1}\frac{5}{15} = 18.43°$

$E^2 = E_1^2 + E_2^2 - 2E_1E_2\cos\theta$

$\theta = 63.43°$

$E_1 = \frac{kQ}{r} = \frac{9\times10^9(4\times10^{-6})}{0.05^2+0.15^2} = 1.44\times10^6\,\frac{N}{C}$

$E_2 = \frac{9\times10^9(4\times10^{-6})}{0.05^2+0.05^2} = 7.2\times10^6\,\frac{N}{C}$

$E^2 = 1.44^2 + 7.2^2 - 2(1.44)(7.2)\cos 63.4°$

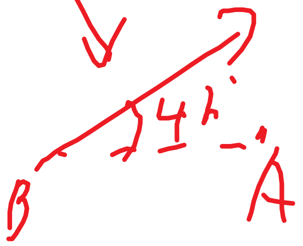
~~$E = 7.9\times10^6\,\frac{N}{C}$~~

$6.68\times10^6\,\frac{N}{C}$

$\frac{\sin\phi}{\ldots} = \frac{\sin 63.4°}{6.68}$

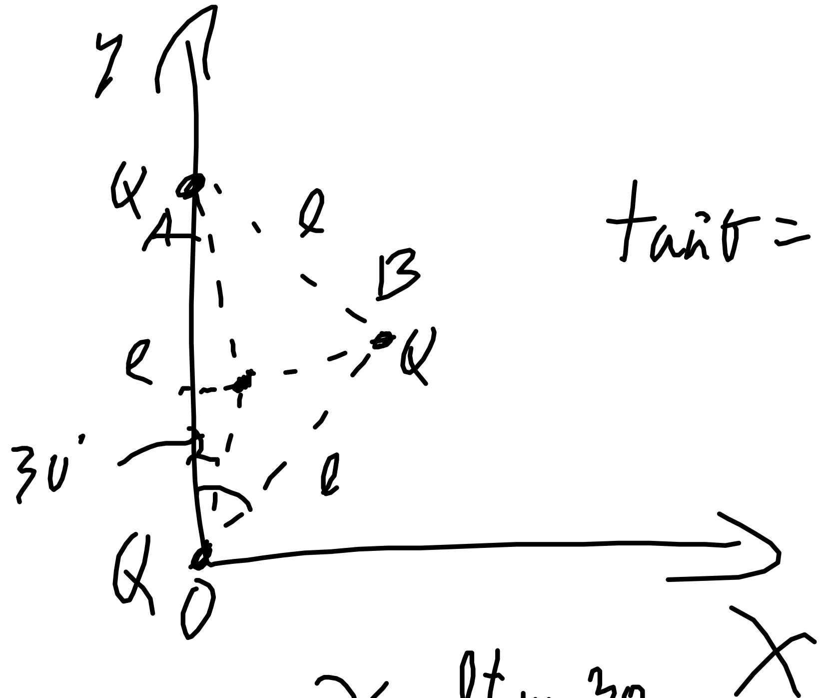
$$\frac{\ldots}{7.2} = \frac{\ldots}{6.68}$$

$\phi = 745°$

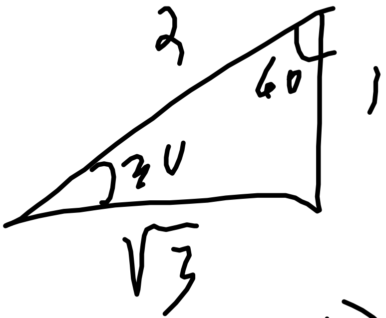


42° above A-B line towards A

Q23

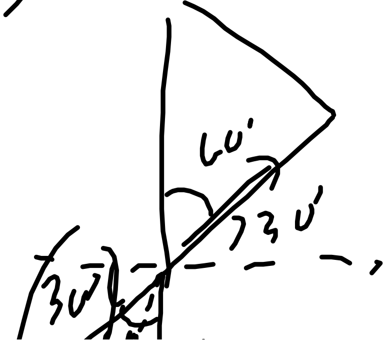


$\tan\theta = \frac{x}{y}$

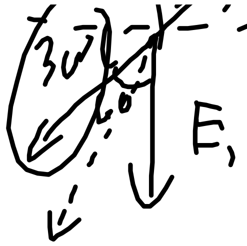


$x = \frac{l}{2}\tan 30$

$x = \frac{l}{2\sqrt{3}}, \quad y = \frac{l}{2}$



$E = 2\frac{kQ}{\ldots}\cos 30$



$$E = 2\frac{kQ}{\ell}\cos 30$$